INTRODUCTION

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There is an old saying that states that the only thing you can always count on is change. Mostly, change is good. There are times, however, when a radical change completely removes the old and takes over. A good example of this is the ice industry of the 1800s and early-1900s in the United States and Europe. Many of our great-grandmothers would talk about the icebox that everyone had in their kitchen and how they would wait for the iceman to come with his horse-drawn wagon, selling the ice for 10 cents for a medium-sized chunk. He would bring the chunk of ice into the house holding it with large ice tongs that pierced the ice so it wouldn't drop. Huge storage buildings had been built to store the ice that had been laboriously cut from the winter lakes. These buildings were insulated with heavy layers of sawdust and, in most cases, were recessed into the ground to keep the warmer summer air from melting the ice. Many full-size cargo ships were built to transport huge shipments of ice from the frozen freshwater lakes in northern Canada to the railcars at U.S. harbors for distribution to cities and homes around the country. This was a vast industry with hundreds of thousands of workers involved in the business.

In 1927, GE introduced the first home-size and affordable refrigerator. By 1950, more than 80 percent of American farms and more than 90 percent of urban homes had one. The ice industry as it had been completely disintegrated.

In like manner, it is totally possible that a new technology can spring up and take over an existing market for products currently produced in high volume. Several leading-edge companies are working on various processes that can have drastic effects on the tried and proven products being used today. Anyone who wants to stay at the forefront of his business always needs to stay aware of the new technologies, understand how they can affect the future, and position himself to take advantage of those changes.

In the electronics field, the advent of stacked packages has become a major new required trend for new products. The customer wants to know how he can get more into a package and use any additional board space. The natural answer is to stack the die into the same package. To obtain this capability of stacking die, a backgrinding process needs to be done to thin the wafers to a level where they can meet the stackup requirements. The paper from Synova SA, by Ochélio Sibailly, Frank Wagner, and Bernold Richerzhagen, titled "Laser-Edge Grinding of Thin Wafers with the Water-Jet-Guided Laser," shows a technique of cutting the damage areas off the edges of a wafer so the micro cracks don't propagate into the good areas of the wafer. The fact that this is done inside a water jet offers several advantages.

The second paper, by D.R. Frear of Motorola, titled the "Emerging Materials Challenges in RF Electronic Packaging," gives a good background into the design and speed issues related to the RF materials and package design. This paper goes into some detail contrasting wirebond and flip chip packages and how this affects the RF properties of the finished product. The effects of different substrate and encapsulation materials are also reviewed with some guidelines for product designs.

These papers give you a feel of the types of things that are going on to promote the next generation of packaging technology. Future additions of this magazine will outline even more radical technologies and discuss how they will impact future programs.

So the next time you sit back on a hot summer day holding a cold drink, watching the ice floating around in it, remember the innovations of change and the impact that these disruptive technologies can have on the currently accepted products. Remember refrigeration and its effect on the world and the jobs of hundreds of thousands of people. Contemplate: is there a technology out there waiting to take your job?

Laser-Edge Grinding of Thin Wafers with the Water-Jet-Guided Laser

During the past 10 years, the Laser Microjet® (water-jet-guided laser) has been continuously optimized, responding to specific market demands, which are increasingly more diversified and ever more demanding. Due to chip volume optimization and technical requirements, the semiconductor industry is obliged to reduce the wafer thickness. Wafer handling is extremely critical for silicon wafers with thicknesses less than 100 microns, due to the brittleness of the wafer edge. The fragility of the wafers is due to micro-cracks omnipresent along the edge, tending to propagate when subjected to the slightest mechanical solicitation.

The Laser Microjet technology provides unprecedented capability for the removal of the problematic micro-cracks. The water-jet-guided laser is especially adapted for thin wafers, due to the absence of thermal damage, mechanical stress, and excellent cutting quality (parallelism, smoothness). It has been shown that the edge grinding by Laser Microjet can reduce wafer breakage to zero.

The overall challenges posed by thin wafer processing and the characteristics of Synova's Laser Microjet technology make it the sole, efficient method for the edge-grinding of thin wafers.

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Introduction

Over the past months, the Laser Microjet System developed by Synova SA in Switzerland has increased its popularity in the semiconductor industry. If its primary application is the efficient chipping-free dicing of silicon wafers, it has proven itself to be very attractive for less common operations, as well.

One of the most promising uses was developed and implemented for the very specific domain of thin-wafer processing (less than 100 microns). The interest of thinning the wafers stems from the interest to gain space, flexibility, or to conform to technical requirements. The gain of space, for example, is critical for multi-chip packages, as well as mobile electronic devices. Mechanical flexibility of the chip is indispensable for smart cards and smart-label applications, RFID devices, stacked memory chips, and others. Concerning diodes and thyristors, the wafer thickness must correspond to a specific amount.

The front-end processing in chip fabrication is carried out using standard-thickness silicon wafers (about 700 microns). Before the wafer is completely finished with backside processes; the wafer is mechanically ground to a thickness of typically less than 300 microns, sometimes as far down as 50 microns, followed by a chemical spin etching. This thinning creates a knife-like sharp wafer edge, which is sensitive to mechanical stress, thus leading to wafer-crack. After the thinning process, several processing steps still need to be carried out. The handling of the thin wafer during these process steps is extremely critical because of the micro-cracks, and wafer breakage rate is very high.

Already in this phase, the wafer is very valuable because the majority of the process steps are finished, hence the money loss per wafer nearly equals the value of the final product.

Therefore, it was critical to find a method for detecting edge damage and its subsequent removal in order to avoid the high wafer breakage rate.

Today, no optical system is able to detect the cracks and no technology exists to treat the sensitive edge of thin wafers. Therefore, why not cut away the regions with micro-cracks around the edges of the wafer? A simple idea, but the requirements for the applied cutting technology are very high. In fact, the cutting process should apply no mechanical constraints on the thin wafer to avoid breaking the wafer during the cutting step. In addition, the cutting technology must not induce new micro-cracks by thermal or mechanical stress. Lastly, the process needs to be fully automatic, from cassette to cassette, and follow precisely the outline of the wafer.

The answer is to use Synova's Laser Microjet technology to literally grind the brittle edges of the thin wafers.

Indeed, the laser dicing system combining a laser source and a hair-thin, low-pressure water jet had already proven its efficiency on thin wafers as pertains to precision and quality.[1] The efficiency of the system revealed itself to be just as advantageous in grinding the edges as in cutting chips. Classical laser cutting may remove the edge too, but due to the thermal load of the wafer, new micro-cracks will be generated in the heat-affected zone of the cut. In conclusion, classical laser cutting is not an alternative.

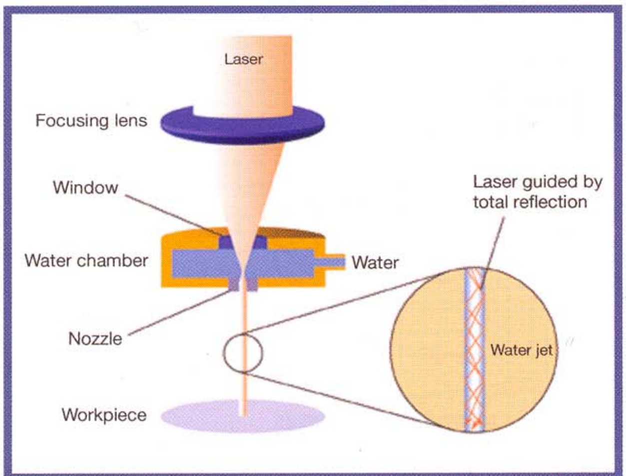

Figure 1. Microjet principle.

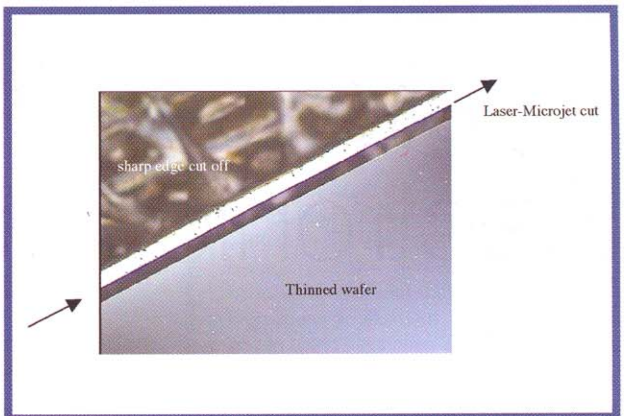

Figure 2. Details of laser-grinded wafer, 70 microns thick. On the lower right corner of the picture the wafer surface is visible. The cut was conducted parallel to the edge of the wafer separating a thin ring of silicon (about 50 microns wide) from the main part. The separated ring is whitish in the picture.

Laser Microjet Principle

In order to couple the light into the water jet, the laser beam is focused into a nozzle while passing through a pressurized water chamber (see Figure 1). The water jet emitted from the nozzle guides the laser beam by means of total internal reflection at the water-air interface, in a manner similar to conventional glass fibers. The water jet can thus be referred to as a fluid optical wave-guide of variable length.

The main advantages of this method compared to conventional laser cutting are:

- Free of burrs and deposition;
- Very low thermal load of the sample due to the cooling between the laser pulses exactly at the place where it was heated before;
- Efficient expulsion of the melted material due to the high momentum of the water jet, therefore high speed especially in the case of thin stencils; and
- Very small tool radius of as low as 14 microns.

Since the entire process is automated and the cutting realized by the laser; the wafer is not subjected to unnecessary mechanical stress throughout the entire process. Furthermore, the precision of the machine allows the diameter to be reduced in very small increments (typically 50 microns), minimizing the loss of precious material.

Laser Grinding System

The Laser Dicing System (LDS 200) machine of Synova was created originally for thin wafer dicing. The market demand for a versatile edge-grinding technique has lately led to the modification of the handling system in order to process the edges of thin wafers without tape support. The machine is fully automatic and supports wafer sizes of up to 8 inches. It is called Laser Grinding System (LGS200A) and is cleanroom compatible.

In general, it is during the cutting of the thinnest wafers that the highest speeds can be achieved. (The dicing speed is up to 200 mm/s for a 50 micron-thick wafer, and up to 50 mm/s for a 200 micron-thick wafer.)

Thanks to the flexibility of the machine, all wafer diameters, wafer shapes and various thickness can be tooled. Substantial yield improvements have been achieved with the water-jet-guided laser in the case of processing thin wafers, because wafer losses caused by micro-cracks are reduced to zero.

Outlook

In a second phase, the laser edge-grinding will be optimized by an automatic detection of micro cracks by image treatment. Afterward, the tool will be able to cut out the cracks permitting the wafer, which would normally break with 100 percent probability, to be saved.

After establishing this technology for Silicon, the edge grinding of GaAs wafer is under investigation. For this purpose, another wavelength is tested, increasing cutting speed as well as quality of the cut. Initial results are very promising.

The Laser Microjet is the sole, efficient solution for thin wafer edge-grinding.

References

[1] Dushkina N., Richerzhagen B., Dicing of GaAs wafers with Synova laser: Microject – Challenges, improvements and safety issues, Technical Digest, ICALEO, 94, 2002.

Biographies

Ochélio Sibailly

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Dr. Frank Wagner

Dr. Frank Wagner received his M.Sc. degree in physics at the University of Göttingen, Germany, and his Ph.D. in micro-technology from the Swiss Federal Institute of Technology Lausanne, Switzerland. As process R&D manager, his main interest today is the continuous improvement of the water jet-guided laser technology.

Dr. Bernold Richerzhagen

Dr. Bernold Richerzhagen received his M.Sc. in mechanical engineering from Aachen Polytechnic in Germany (RWTH) and his Ph.D. in micro-technology from the Swiss Federal Institute of Technology Lausanne. He became CEO of Synova SA in 1997. He is acknowledged as the inventor of water-jet-guided laser technology.